

U.S. EPA Region 8
Underground Injection Control Program

AQUIFER EXEMPTION DRAFT RECORD OF DECISION

This Draft Record of Decision provides EPA's aquifer exemption (AE) decision, background information concerning the AE request, and the basis for the AE decision.

Regulatory Agency: U.S. EPA Region 8

Date of Aquifer Exemption Application Request: March 18, 2016

Operator: WPX Energy Williston, LLC

Well Class/Type: Class II Salt Water Disposal (SWD)

Well/Project Name: Pennington SWD #1

Well/Project Permit/Docket Number: ND22335-10898

Well API number: 33-061-90351

Field: Van Hook

Tribal Reservation: Ft. Berthold Reservation

Well/Project Location: Qtr: SENE Section: 2 Township: 150 N Range: 92 W

Footage Calls: 1104 feet from N line 342 feet from E line

County: Mountrail **State:** North Dakota

Latitude: 47.844668°

Longitude: -102.408607°

PROJECT BACKGROUND INFORMATION

The Pennington SWD #1 is a Class II disposal well for produced water generated by oil field production from the Bakken/Three Forks Formation in the Williston Basin owned/operated by WPX Energy.

DESCRIPTION OF PROPOSED AQUIFER EXEMPTION *(depths are approximate values at the well bore)*

Aquifer(s) to be Exempted

Formation: Inyan Kara Formation (Dakota Group) *Top:* 4,762 feet *Bottom:* 5,200 feet

Lithology: Sandstone

Description and Areal Extent of Aquifer(s) Proposed for Exemption *(radial distance from wellbore, PLSS description):* 1,320 foot radius centered on the well bore that is located 1104 feet from the North Line and 342 feet from the East Line of Section 2, T 150 North, R 92 West, Mountrail County North Dakota. A minor modification to the permit will be made to limit the total injected volume to 62.7 million barrels of produced water. This allowable volume under the permit is calculated by using the net sand thickness (286 feet), a porosity of 22.5% within the injection zone and applying a radius of 1,320 feet.

Total Surface Area of Aquifer to be Exempted: about 125.7 acres (ac) (0.19 Square Miles)

Water Quality Data of the Aquifer Proposed for Exemption

Aquifer Water Quality – TDS (mg/L): 7,080 and 7,720

Source of WQ Data: On August 29, 2016, WPX collected water samples from the Inyan Kara Formation (Dakota Group) perforations between 4,797 feet - 5,203 feet in the Pennington #1 SWD well. The samples were analyzed by SGS North America Incorporated and other laboratories. The results of those analyses are summarized in Table 1 and Table 2.

Table 1 - SGS Laboratories Analytical Data

	pH (S.U.)	Specific Conductance (mS/cm)	Total Dissolved Solids (TDS) (mg/L)	Specific Gravity
Analytical Method	SM 4500H+B	SM 2510B	SM 2540-C	ASTM 4052
Inyan Kara	7.35	9230	7080 / 7720	1.0035

The analyses included anions and cations, metals (total and dissolved) (USEPA method 200.7), semi-volatile organics (USEPA method 8270), organics (USEPA method 8260), total Petroleum Hydrocarbons (USEPA method 8015) and radiological constituents.

Because the Inyan Kara in this area is below 10,000 milligrams per liter (mg/l) total dissolved solids (TDS), it is considered to be an Underground Source of Drinking Water (USDW). It is also considered to be hydrologically isolated from formations receiving injected produced water from nearby oil field operations approximately 4,000 feet deeper than the base of the Inyan Kara Formation. This sampling is intended to more fully characterize the chemical nature of the groundwater in the Inyan Kara Formation. Specifically, 209 individual compounds and parameters were analyzed during this sampling event.

The following table represents selected results of the August 29, 2016, sampling and analysis of the Inyan Kara Formation groundwater in the Pennington #1 SWD well. The chemicals in this table are those that have values that exceed the USEPA Primary and Secondary drinking water standards.

Table 2 – Summary Table of Inyan Kara Formation selected groundwater results

CONSTITUENT	UNITS	VALUE	USEPA DRINKING WATER STANDARDS	
			Primary MCL	Secondary MCL
Chloride	mg/L	3380		250
Total Dissolved Solids (TDS)	mg/L	7080-7720		500
Total Iron	mg/L	28.3		0.03
Total Lead	mg/L	0.653	0.015	
Total Manganese	mg/L	0.397		0.05
Dissolved Manganese	mg/L	0.228		0.05
Benzene	ug/L	11.8	5	
Radionuclides				
Gross Alpha	pCi/L	380	15	
Radium 226	pCi/L	10	5	
Radium 228	pCi/L	8.7		

Note: Secondary drinking water standards are not enforceable, however, they may pose undesirable aesthetic, cosmetic and technical effects to drinking water.

As discussed below, these constituents of the native groundwater of the Inyan Kara Formation indicate the need for water treatment to be a suitable source of drinking water. Additional constituents were also detected but were not above drinking water standards, including metal, semi-volatile, volatile and petroleum hydrocarbon compounds.

Confining Zones

Upper: Skull Creek, Mowry, Belle Fourche, Greenhorn, Carlile, Niobrara, and Pierre Shales
Lithology: Shale

Top: 1,651 feet *Bottom:* 4,760 feet *Thickness:* 3,109 feet

Lower: Jurassic Swift *Lithology:* Shale

Top: 5,200 feet *Bottom:* ~5,627 feet *Thickness:* 427 feet

Immediately above the injection zone and within the Dakota Group are the Skull Creek Shale (107 feet) and Mowry Shale (224 feet) for a total thickness of 331 feet.

Above the Dakota Group is the Colorado Group, which is 902 feet thick, consisting of the Belle Fourche Shale (217 feet), Greenhorn Shale (180 feet), Carlile Shale (215 feet) and Niobrara Shale (290 feet).

Also, above the Colorado Group is the Montana Group, consisting of the Pierre Shale, which is 1,876 feet thick at the Pennington #1 SWD well. Any USDW intersecting the Pennington #1

SWD wellbore above the injection zone is protected by approximately 3,109 feet of impermeable shale as listed above.

Below the injection zone, the lower confining zone consists of the Jurassic Swift Formation, which is approximately 427 feet thick at the nearby Slawson Revolver 2-35H production well. The Slawson Revolver 2-35H well is 1,661 feet north of the Pennington #1 SWD. This lower confining unit consists primarily of impermeable shales.

Demonstration that the injectate will remain in the exempted portion (*Consider injection rate, volume limits, injection pressure, TDS of the injectate, etc.*)

The net sand thickness calculated by the EPA was estimated at 286 feet of clean sands within the Inyan Kara at this location. The Average Bulk Density from a log analysis is 2.302 grams/cubic centimeters. Using these values resulted in an Average Bulk Density Porosity value for the clean sands in the injection zone of 22.5 %.

Based on the estimates above, WPX can inject no more than 62,700,000 bbls of produced water (to fill the pore space) into the Inyan Kara Formation to ensure that fluids remain within the ¼ mile radius of the wellbore proposed for exemption. Additionally, upper and lower confining zones have been identified and verified by analyzing cement bond logs to confine the fluids within the injection zone.

IDENTIFICATION OF OTHER USDWs in the AREA (*Identify the source of data, if available*)

The principal sources of drinking water in the area of the proposed aquifer exemption are the New Town Aquifer and the Sanish/White Shield Aquifer which are USDWs that are between 0 and 237 feet below the ground surface.

Additionally, other USDWs within the region include the Fort Union Group, which is also used to supply domestic water wells, the Sentinel Butte, Hell Creek and Fox Hill aquifers. These units are found between 237 feet and 1,688 feet below the ground surface.

INJECTATE INFORMATION (*Injectate characteristics including water source and water quality*)

Table 3 illustrates the chemical parameters representative of produced waters from WPX production wells in the Van Hook field.

Table 3. Produced water analysis – WPX production wells

Total Dissolved Solids (TDS) (mg/L)	pH	Sodium Chloride (mg/L)	Cations							Anions				
			Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Iron (mg/L)	Chromium (mg/L)	Barium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Carbonate (mg/L)	Bicarbonate (mg/L)	Sulfate (mg/L)	Nitrate (mg/L)
281,112	5.34	279,492	18,683	1,666	85,100	150	0.6	20	5,645	169,494	0	114	241	0
Average of six samples from WPX producing wells														

BASIS FOR PROPOSED DECISION

Regulatory Criteria under which the aquifer exemption is requested.

146.4: ☒ (a) This aquifer is not currently used as a drinking water source:

- Personal communication with North Dakota State Water Commission indicates there are no domestic, stock or municipal water wells completed in the Dakota group (which includes the Inyan Kara formation) on the western side of North Dakota;
- Domestic water wells in the area are primarily supplied from the New Town Aquifer, Sanish/White Shield Aquifer, and the Fort Union Group. The nearest domestic well to the Pennington SWD #1 is located at a depth of 308 feet and a distance of 6.95 miles;
- The City of New Town, North Dakota, water supply consists of four (4) ground water wells penetrating the New Town Aquifer at a depth 178 – 196 feet. The nearest municipal well is located approximately 10 miles from the Pennington #1 SWD.

146.4 (b) The aquifer cannot now and will not in the future serve as a source of drinking water:

☒ (b)(2) *It is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical.*

The primary factors controlling the cost of developing the proposed exempted aquifer as a possible drinking water source are depth and water quality. The Inyan Kara is found at approximately 4,758 feet below land surface with a total depth of 5,204 feet and TDS of 7080-7720 mg/l. In contrast, aquifers currently utilized at shallower depths as described below in Table 5 are the New Town Aquifer, Sanish/White Shield Aquifer, and the Fort Union Group, as well as the better quality Hell Creek Formation (272 feet thick at a depth of 1,205 feet) and the Fox Hills Formation (172 feet thick and is available at a depth of approximately 1,477 feet and TDS of 1,530 mg/l). In general, the overlying USDWs are of better quality and because they are much shallower and are less costly to develop.

The processes for treating the constituents noted above for developing the Inyan Kara Formation as a possible source of drinking water may include, but are not limited to:

- Dissolved Air Flotation
- Lime Softening
- Microfiltration
- Two Pass Reverse Osmosis
- Carbon Adsorption
- Remineralization

These treatment processes would likely need to be installed at the well-head as pumping Inyan Kara water any significant distance in a pipeline would likely have significant corrosive effects increasing the risk to pipeline failure. Therefore, it would be uneconomical to consider drilling a water supply well into this Formation unless the well was located as near as possible to potential users (e.g., New Town, North Dakota).

The capital cost of drilling a water supply well is estimated to be \$1,076,950 as noted in Table 4.

The estimated capital cost for the construction of the treatment plant is \$10,500,000. Monthly operations and maintenance (O&M) costs are estimated to be \$269,500. The O & M costs do not include the costs for disposal of sludges and high concentration brines that would be generated by treatment of the Inyan Kara water. The brines and sludges would likely need to be transported to an approved disposal facility. The costs for the disposal of these wastes would vary based upon their composition.

It is estimated that approximately 170,000 gallons of highly saline reject water would be generated by the treatment plant per day that will require disposal. It is estimated that \$224,643 would be the minimum needed per month to pay for disposal and haulage costs for the reject water.

In addition, approximately 325 tons per month of sludge from the water treatment plant would require disposal. Assuming that the sludge would not be hazardous or contain radioactive constituents, the disposal costs for the sludge would be approximately \$60 per ton. Sludge disposal would result in a monthly cost of \$16,250. If the sludge is determined to be hazardous or contain radioactive constituents the cost for sludge disposal would be approximately three times this cost or approximately \$52,000 per month.

The well is estimated to yield 670 gallons per minute (gpm). However, due to anticipated treatment plant operations and maintenance requirements, the well would only be able to operate 25 days per month thereby reducing the maximum yield to approximately 570 gpm.

The overall development costs of using Inyan Kara Formation groundwater (~4,800-5,200 feet in depth) as a public water supply compared to available shallow aquifers (~250 feet in depth) in/around New Town, North Dakota, is as follows:

- Current New Town water rates for a family of four - \$4.99/ 1000 gallons
- Inyan Kara Groundwater development per well assuming a two year amortization - \$45/1000 gallons (900% increase to the user over current costs)
- Inyan Kara Groundwater development per well assuming a ten year amortization - \$24/1000 gallons (500 % increase to the user over current costs)

It should also be noted that the current water supply for New Town is relatively shallow and there are likely additional aquifers that may produce sufficient drinking water at lower cost and better quality. These more shallow USDWs occur between the base of the Sanish/White Shield aquifer system to the base of the Fox Hills Formation that is approximately 1,492 feet below ground surface.

Table 5 below indicates approximately 7.6 M acre-feet (ft.) of available ground water resources for the New Town Peninsula, where the Pennington#1 SWD well is located. The New Town Peninsula is the area south of New Town and bounded in part by Lake Sakakawea. The relatively low TDS of these shallower aquifers thereby minimizes the amount of treatment needed for use as a domestic or public water supply well. Additionally, surface water resources are available from Lake Sakakawea that is located one mile from the Pennington #1 SWD well.

The Lake holds a permanent pool of 4,980,000 acre-feet with a maximum capacity of approximately 24 million acre-feet. A useable volume of up to 18,841,000 acre-ft. is available for the operation of all six of the main stem dams on the Missouri River. (Personal communication in March 2016 with Mr. Todd Lindquist, U.S.Army Corp of Engineers; Missouri River Mainstem Reservoir System; Master Water Control Manual, 2006.)

For the analysis below, it is estimated that a 5-1/2" and 7" cased domestic water well would cost approximately \$35.00/foot to drill. The Inyan Kara costs are based on a drilling cost of approximately \$64.00/foot because of the depth and required casing size. The estimates below also include the internal well requirements to extract the groundwater for use (e.g., permanent pumping equipment).

Table 4 – Estimated Cost to Drill Public Water Supply Well

Aquifer	Depth	5-1/2" Casing	7" Casing
	Feet	Estimated Cost	Estimated cost
Tongue River	200	\$ 67,948.50	\$73,513.00
Hell Creek	1,107	\$117,201.00	\$139,110.00
Inyan Kara	4,800	NA	\$1,076,950.00

Note:

Inyan Kara costs based upon a larger diameter (8 inch casing) well because of the depth to the formation.

Estimates noted in the table, are based on a 200-ft. well into the Tongue River aquifer, 1,107-ft. well into the Hell Creek aquifer, and a 4,800-ft. well in the Inyan Kara.

**Table 5 - Available Water Resources for the New Town Peninsula
(USGS Report 98-4098)**

Resource	Average Thickness (ft.)	Mean TDS (mg/l)	New Town Peninsula Volume (acre-ft.)	Total Volume (acre-ft.)	Areal Extent (mi²)
New Town Aquifer	50	1,390	170,000	170,000	18
Sanish Aquifer	125	1,350	240,000	240,000	8
Sentinel Butte Aquifer	100	1,300	1,250,500*	18M	914
Tongue River formation (Ft. Union)	80	2,110	1,925,500*	24M	1583
Hell Creek/Fox Hills Aquifers**	200	1,530	4,091,600*	51M	1583

*estimated

**The Hell Creek and Fox Hills formations are connected hydrologically and are therefore considered to be a single aquifer. This combined aquifer underlies the entire Reservation and ranges from 100 to 350 feet in thickness.

Based on the comparative estimated costs to drill a water well into the Inyan Kara, Fox Hills/Hell Creek, and Tongue River aquifers, and considering other supplies located at shallower depth, it is very unlikely that the Inyan Kara aquifer would ever be developed as a drinking water source. Additionally, there is a sufficient quantity of water available from current supplies without the development of the proposed exempted portion of this aquifer. Finally, the Inyan Kara formation is utilized as an injection zone elsewhere in the state of North Dakota for 44 permitted injection wells including five on the Fort Berthold Reservation.

Table 6 shows North Dakota county population projections for the counties adjacent to the Fort Berthold Reservation, obtained from the North Dakota Department of Commerce – Census Office, <http://www.commerce.nd.gov/census/>.

Table 6 – North Dakota County Population Projections

North Dakota Counties	2010	2025	2020	2025	2030	2035	2040	% Increase 2010- 2040
Dunn County	3,536	4,619	5,437	6,147	6,654	7,006	7,249	51%
Mountrail County	7,673	10,314	12,364	14,191	15,587	16,607	17,367	56%
McKenzie County	6,360	12,193	16,568	20,480	23,492	25,691	27,361	77%
Mercer County	8,424	8,819	9,059	92,215	9,283	9,271	9,206	8%
McLean County	8,962	9,737	10,332	10,870	11,275	11,519	11,673	23%
Ward County	61,675	71,243	79,053	86,157	91,644	96,037	99,607	38%
							Avg. Inc.	42%

It is estimated the adjacent counties will increase in population by an average of 42% by 2040. Using the same percent increase, the population on the Fort Berthold Reservation could increase from the current population of 6,341 (2010 population data taken from the North Dakota Indian Affairs Commission “Statics and Data: Statewide data: Mandan, Hidasta and Arikari Nation; <http://www.nd.gov/indianaffairs/?id=37>”) to 9,004 in 2040.

The EPA’s website (https://www3.epa.gov/watersense/our_water/water_use_today.html) states the average American family uses approximately 300 gallons of water per day. Assuming the average family consists of four people, an individual will use approximately 75 gallons of water per day or 27,375 gallons per year. This calculates to 0.084 acre-ft. of water per person per year. Annual water requirements for 9,004 people would be 756.45 acre-ft./year. Therefore, 7.6 Million (M) acre-ft. of available water in shallower aquifers, noted in Table 3, can provide water requirements for domestic/public water use on the Reservation for many years into the future.

Based on the above information, there is sufficient quantity of water available at shallower depths and of better quality to supply current and future populations of the Fort Berthold Reservation without the development of the Inyan Kara aquifer at this location as a source of drinking water. Therefore, the EPA has determined that this portion of the Inyan Kara aquifer is situated at a depth and of a quality that makes recovery of drinking water economically impractical.

146.4 ☒ (c) TDS of the aquifer is more than 3,000 mg/l and less than 10,000 mg/l and so this aquifer is not reasonably expected to supply a public water system.

A water sample was taken of the Inyan Kara Formation from the Pennington #1 SWD well during recent sampling (August 29, 2016) was found that the TDS was determined to range between 7,080 mg/l and 7,720 mg/l. The above discussion under the 146.4 (b)(2) exemption criterion directly supports the conclusion that the Inyan Kara Formation is not reasonably expected to supply a public water system.

PUBLIC COMMENT

Public Comment Process: A 30-day public notice period for this proposed aquifer exemption will be posted on the Region 8 EPA Underground Injection Control website and an announcement of this notice was published in the *New Town News*, *MHA Times* and *Minot Daily News*. All surface land owners within one-quarter mile of the Pennington #1 SWD well were also notified of the opportunity for public comment.

CONCLUSION AND DECISION

Based on review of the entire record, the EPA finds that exemption criteria 40 CFR §§ 146.4(a), 146.4(b)(2), and 146.4(c) have been met and the EPA proposes to approve as a non-substantial program revision to include exemption of portions of the Inyan Kara Formation pending the results of the public comment period.